Pelton Turbine Experiment

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المرحلة الثالثة

الشعبة B

Calculations

T= F x r

$T_1 = F_1 \times r = 4.25 \times 0.16 = 0.68$ N.m
$T_2 = F_2 \times r = 5.75 \times 0.16 = 0.92$ N.m
$T_3 = F_3 \times r = 5.75 \times 0.16 = 0.92$ N.m
$T_4 = F_4 \times r = 6 \times 0.16 = 0.96$ N.m
$T_5 = F_5 \times r = 3.5 \times 0.16 = 0.56$ N.m

$$\omega = \frac{2\pi x N}{60}$$

$\omega_1 = \frac{2\pi x 980}{60} = 102.62$ rad/sec
$\omega_2 = \frac{2\pi x 1340}{60} = 140.324$ rad/sec
$\omega_3 = \frac{2\pi x 1550}{60} = 162.3156$ rad/sec
$\omega_4 = \frac{2\pi x 3450}{60} = 361.283$ rad/sec
$\omega_5 = \frac{2\pi x 3510}{60} = 367.287$ rad/sec

h feet → meter → x 0.3048

$h_{10} = 3.048$ m
$h_{20} = 6.096$ m
$h_{30} = 9.144$ m
$h_{40} = 12.192$ m
$h_{50} = 15.24$ m

$$Q = \frac{Q x 0.02831}{60} \rightarrow m^3/s$$

$Q_1 = \frac{4.2 x 0.02831}{60} = 1.9817 \times 10^{-3}$ m^3/s
$Q_2 = \frac{3.6 x 0.02831}{60} = 1.6986 \times 10^{-3}$ m^3/s
$Q_3 = \frac{3 x 0.02831}{60} = 1.4155 \times 10^{-3}$ m^3/s
$Q_4 = \frac{2.4 x 0.02831}{60} = 1.1324 \times 10^{-3}$ m^3/s
$Q_5 = \frac{2 x 0.02831}{60} = 0.94366 \times 10^{-3}$ m^3/s

$P_{in} = \gamma \times Q \times H$

$P_1 = 9810 \times 1.9817 \times 10^{-3} \times 3.048 = 59.25$ W
$P_2 = 9810 \times 1.6986 \times 10^{-3} \times 6.096 = 101.5792$ W
$P_3 = 9810 \times 1.4155 \times 10^{-3} \times 9.144 = 126.9740$ W
$P_4 = 9810 \times 1.1324 \times 10^{-3} \times 12.192 = 135.4390$ W
$P_5 = 9810 \times 0.94366 \times 10^{-3} \times 15.24 = 141.0813$ W

$P_{out} = T \times \omega$

$P_1 = 0.68 \times 102.62 = 69.78$ W
$P_2 = 0.92 \times 140.324 = 129.09$ W
$P_3 = 0.92 \times 162.3156 = 149.33$ W
$P_4 = 0.96 \times 361.283 = 346.831$ W
$P_5 = 0.56 \times 367.287 = 205.678$ W

$$\eta = \frac{P_{in}}{P_{out}}$$

$$\eta_1 = \frac{59.25}{69.78} = 0.8490$$

$$\eta_2 = \frac{101.5792}{129.09} = 0.7868$$

$$\eta_3 = \frac{126.9740}{149.33} = 0.8502$$

$$\eta_4 = \frac{135.4390}{346.831} = 0.3905$$

$$\eta_5 = \frac{141.0813}{205.678} = 0.6859$$

Tables

Table 1

Nozzle valve	Discharge valve	Q ft^3/min	P_d ft	Speed r.p.m	F_d lb
N1	Fully open	4.2	10	980	0.955
N2	Fully open	3.6	20	1340	1.292
N3	Fully open	3	30	1550	1.292
N4	Fully open	2.4	40	3450	1.348
N5	Fully open	2	50	3510	0.786

Table 2

Q_1 m^3/sec	V_1 m/sec	$P_{1(in)}$ Watt
1.9817×10^{-3}	16.419	59.25
1.6986×10^{-3}	22.451	101.5792
1.4155×10^{-3}	25.970	126.9740
1.1324×10^{-3}	57.805	135.4390
0.94366×10^{-3}	58.765	141.0813

Table 3

Head H (m)	Speed N (rpm)	Discharge Q m^3/s	Dynamic force F (N)
3.048	980	1.9817×10^{-3}	4.25
6.096	1340	1.6986×10^{-3}	5.75
9.144	1550	1.4155×10^{-3}	5.75
12.192	3450	1.1324×10^{-3}	6
15.24	3510	0.94366×10^{-3}	3.5

Table 4

Power input	Power output	Efficiency
59.25	69.78	0.8490
101.5792	129.09	0.7868
126.9740	149.33	0.8502
135.4390	346.831	0.3905
141.0813	205.678	0.6859

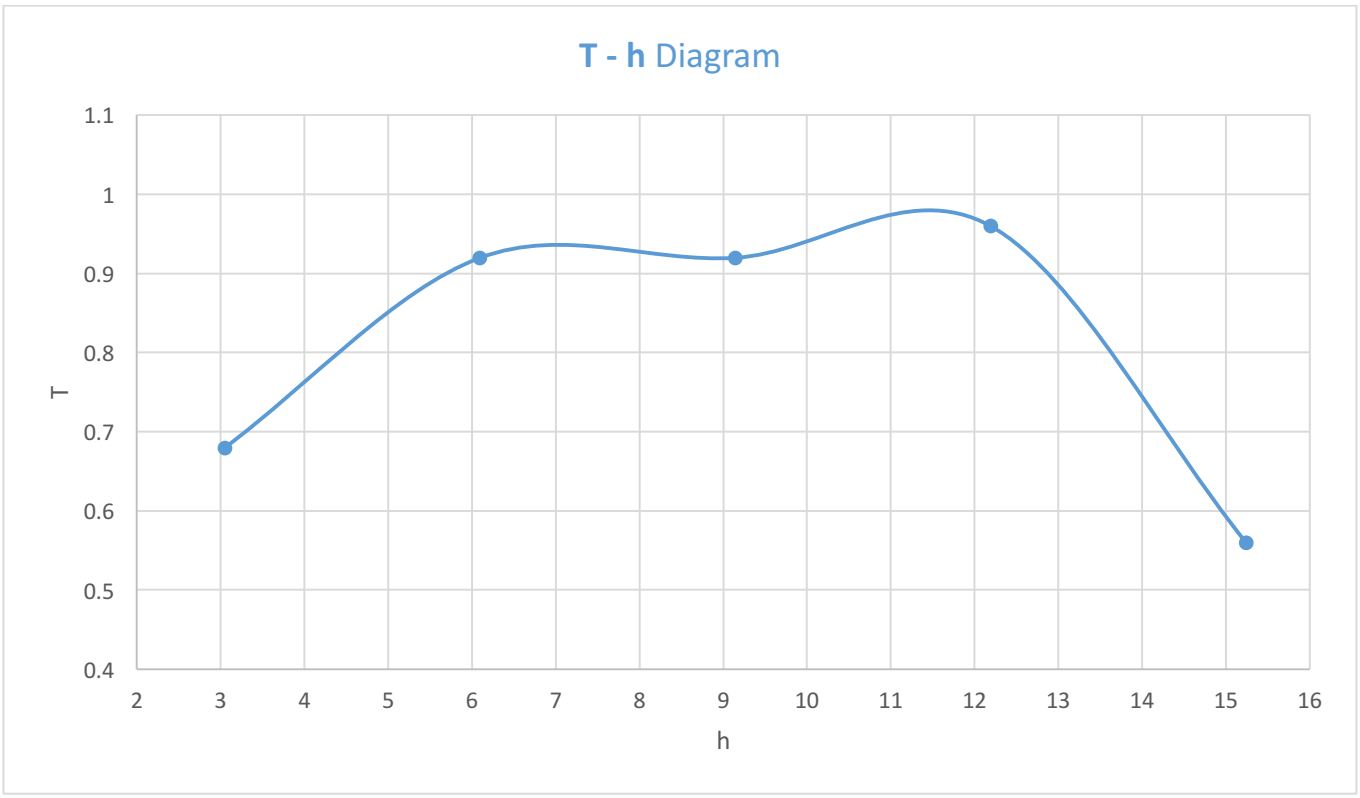
Sheet Solutions (Further Consideration)

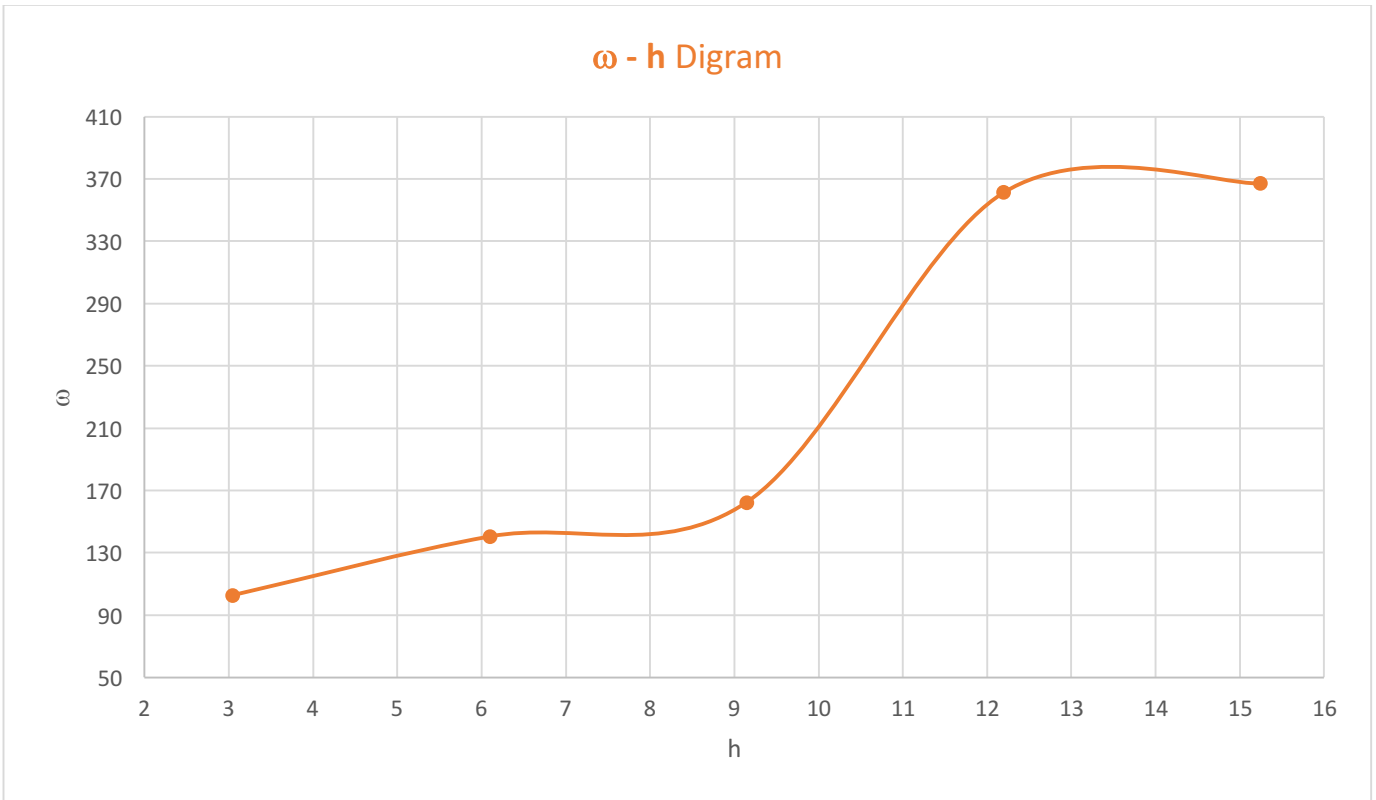
1- The maximum efficiency is at speed 1550 rpm (162.315 rad/s).

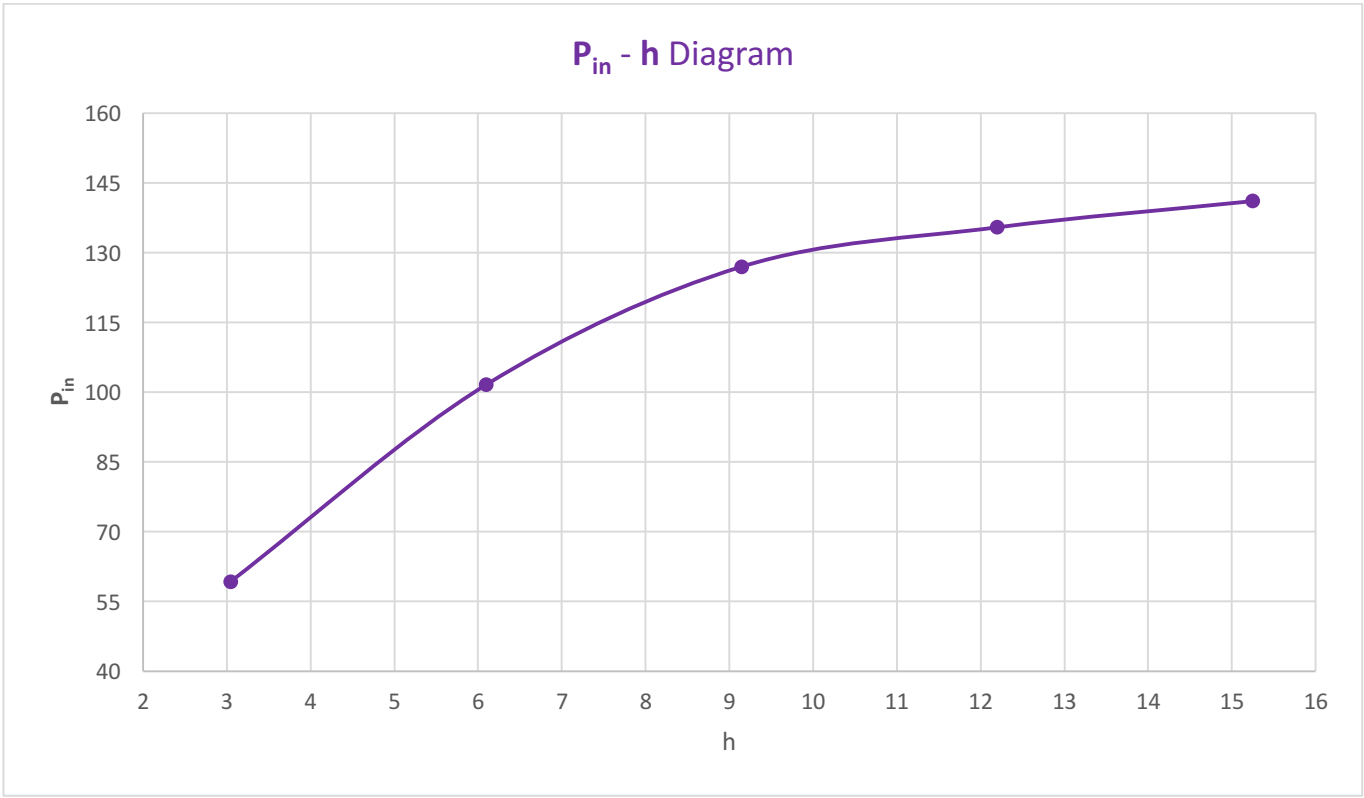
2- The efficiency vanish at zero r.p.m because Pelton's wheel does not move so there's no power input or output.

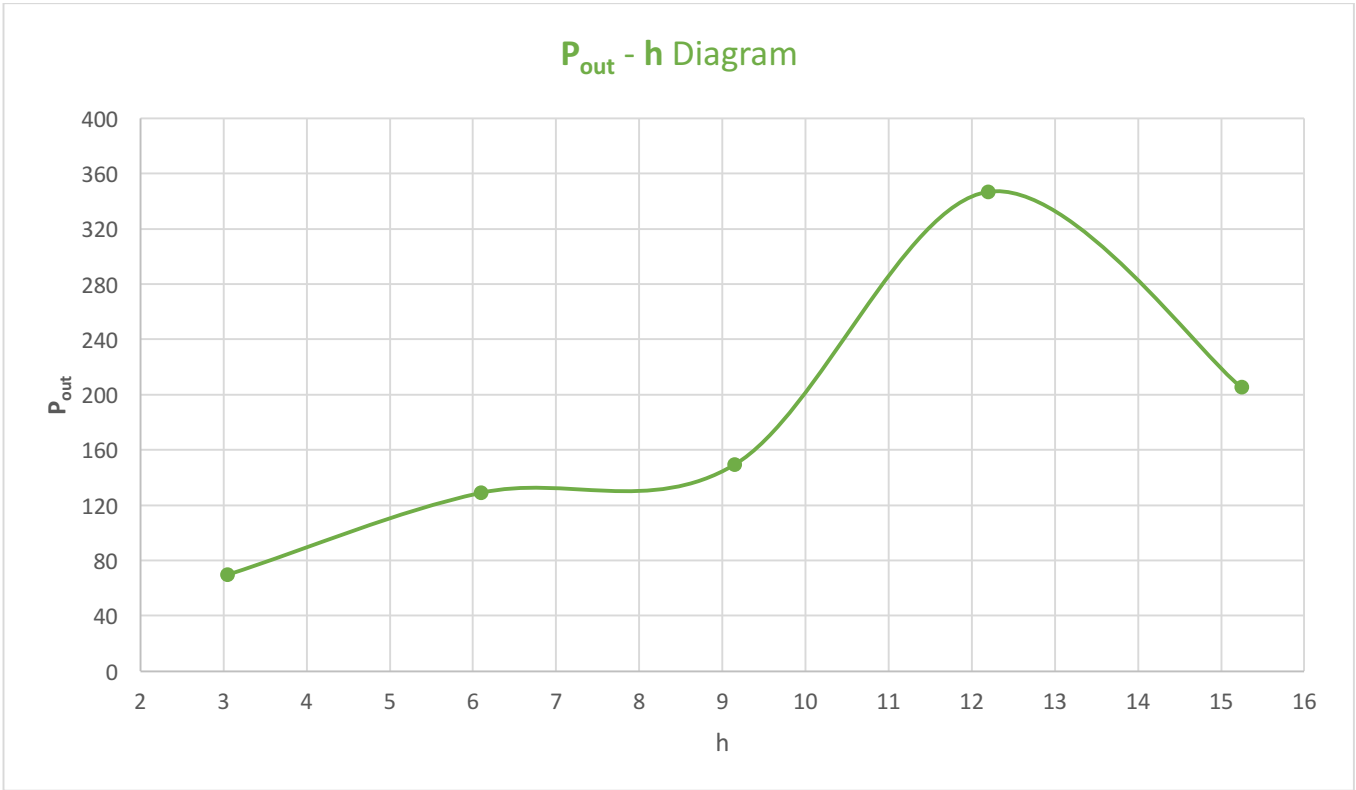
3- In order to increase the efficiency of turbine we have to increase the ratio of power output to energy input, therefore we have to either increase Q and H or decrease T and ω, also worth mentioning the friction has the greatest impact on hydraulic efficiency and in turn hydraulic efficiency is one of the factors affecting the overall efficiency either the friction of the wheel or the friction between the water jet and the cups attached to the wheel . This makes friction an important factor in overall turbine efficiency.

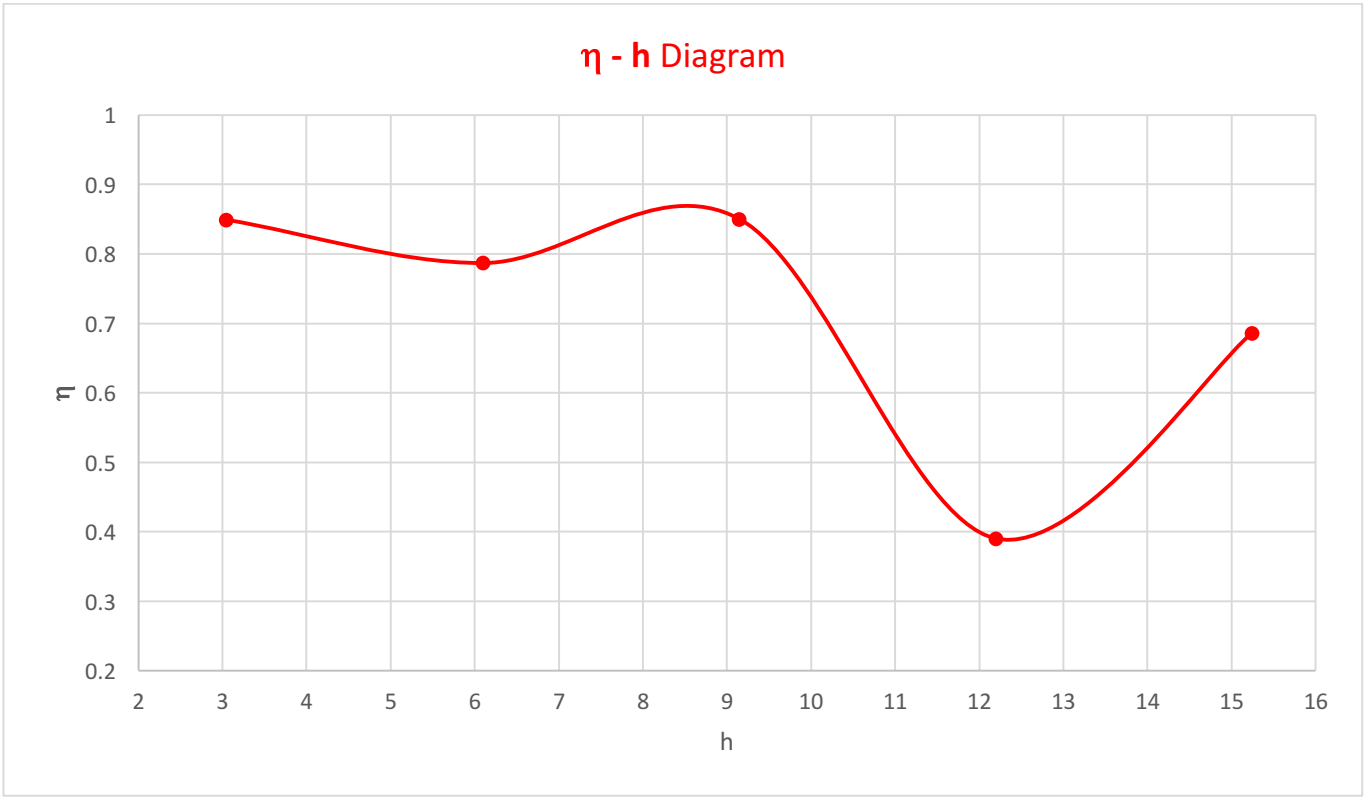
Tables


T - h Diagram
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
T
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
h


ω - h Digram
410
370
330
290
250
210
170
130
90
50
ω
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
h


P_{in} - h Diagram
160
145
130
115
100
85
70
55
40
P_{in}
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
h


P_{out} - h Diagram
400
360
320
280
240
200
160
120
80
40
0
P_{out}
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
h


η - h Diagram
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
η
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
h